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Scallop Fishing Grounds on the Scotian Shelf - 1987

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ABSTRACT

On the Scotian Shelf, scallop beds occur, in a patchwork fashion, from Banquereau Bank to the east to the Lurcher Shoals at the approaches to the Bay of Fundy. Historically, these grounds had never sustained production (measured by catch) for more than a few years until recently when significant effort was diverted to these beds by both the Bay of Fundy fleet, component of the 'inshore' fleet (vessels under 19.8m) and the deep-sea 'offshore' fleet (vessels over 19.8m). The implementation of common regulatory processes on both the inshore and offshore fleets seemed impossible because of different vessel sizes and different fishing patterns. Following an industry seminar in September 1986, an agreement was reached between the two fleets toward the formal separation of grounds fished by the fleets at latitude $43^{0}40'$ North. The inshore fleets are limited to fish north of the line while the offshore fleet is restricted to south of the line.

The traditional fishing patterns of the deep-sea fleet have always included Georges Bank as the main ground exploited with the Scotian Shelf as an alternate, sometimes in an opportunistic fashion. Scotian Shelf scallop beds have become of greater importance and are visited regularly since fishing activities on Georges Bank are directed by an Enterprise Allocations system (E.A's.) for catch removals. Ever since the beginning of the offshore fishery in the late 1950's, exploitation of the Scotian Shelf was somewhat irregular; until the 1980's that is. It now appears that some Scotian Shelf grounds may sustain continuous exploitation. This report examines nominal trends in long-term productivity of the Scotian Shelf and reviews the recent events of the fishery on these grounds.

RESUME

On trouve des bancs de pétoncles parsemés sur le plateau néo-écossais à partir du banc Banquereau à l'est jusqu'aux haut-fonds de Lurcher aux approches de la Baie de Fundy. Du point de vue historique, ces bancs n'ont jamais produit d'une façon soutenue d'après les captures, pour plus de quelques années jusqu'à récemment lorsque la flottille de la Baie de Fundy, élément de la flottille côtière (bâteaux de moins de 19.8m) et la flotte hauturière (bâteaux de plus de 19.8m) y ont appliqué un effort de pêche important. L'implémentation de processus régulatoires communs tant sur la flottille côtière que sur la flotte hauturière paraissait impossible vu les différences de taille des navires et des habitudes de pêche. Après un séminaire en septembre 1986, les deux flottilles en sont venues à une entente pour la séparation formelle des territoires de pêche exploités par les participants à la latitude $43^{0}40'$ Nord. La flottille côtière doit limiter sa pêche au nord de cette ligne tandis que la flotte hauturière demeure au sud de la ligne.

La flotte hauturière a, par habitude, toujours exploité le banc Georges comme lieu de pêche principal et, bien souvent d'une façon opportuniste, le plateau néo-écossais en alternative. Les bancs de pétoncles du plateau ont pris plus d'importance et sont visités régulièrement depuis que la pêche du banc Georges est soumise au régime d'Allocations par Entreprises. Dès le début de la pêche hauturière vers la fin des années 1950, l'exploitation du plateau néo-écossais était plutôt irrégulière; du moins jusque dans les années 1980. Il en ressort maintenant que certains endroits du plateau pourrait soutenir une exploitation continue. Ce rapport examine les tendances nominales de la productivité à long terme du plateau néo-écossais et revise les événements récents de cette pêche.

INTRODUCTION

Noticeable developments have recently taken place in the scallop fishery of the Scotia-Fundy Region. The implementation of common regulatory processes on both the inshore and offshore fleets seemed impossible because of different vessel sizes and different fishing patterns. The issue of access to fishing grounds was the most contentious. Following an industry seminar in September 1986, an agreement was reached between the two fleets toward the formal separation of grounds fished by the fleets. The 'inshore' fleets (L.O.A. under 19.8 m; Bay of Fundy, mid-Bay license holders mainly) are limited to fish scallop beds north of latitude 43^0 40' in Bay of Fundy waters and approaches while the 'offshore' fleet (L.O.A. over 19.8 m referred to as the deep-sea fleet in this document) is restricted south of latitude 43^0 40'. (The Bay of Fundy fleet has access to Georges Bank for 1987 and 1988 under trip permits but is not allowed to fish the Scotian Shelf between latitude 43^0 40' and the northern edge of Georges Bank). This agreement took effect January 1, 1987. Another important management measure in place is a meat count of 33 per 500 g for Georges Bank, Browns Bank and German/Lurcher up to 43^0 40' (NAFO sub-subareas 5Ze and 4Xp and q) and of 45 per 500 g for Middle Grounds, Sable Island - Western Bank area and Banquereau Bank (NAFO sub-subareas 4We, f - j, and 4Vc).

The traditional fishing patterns of the deep-sea fleet have always included Georges Bank as the main ground exploited with the Scotian Shelf as alternate, sometimes in an opportunistic fashion. Scotian Shelf scallop beds have taken greater importance and are visited regularly since fishing activities on Georges Bank are directed by an Enterprise Allocations system (E.As.) for catch removals. Ever since the beginning of the offshore fishery in the late 1950's, exploitation of the Scotian Shelf was somewhat irregular; until the 1980's that is. It now appears that some Scotian Shelf grounds may sustain continuous exploitation. This report examines nominal trends in long-term productivity of the Scotian Shelf and reviews the recent events of the fishery on these grounds.

METHODS

Fishery Information

There are two sources of information to estimate the respective contributions of scallop fishing grounds on the Scotian Shelf. The Statistics Division, Department of Fisheries and Oceans, Halifax, compiles, on a yearly basis, landings by vessel size and by NAFO sub-subareas. Log information as to the origin of the catch provided by vessels is the other source. There are at times discrepancies between statistical and logged catches as NAFO sub-subareas are not tailored to the physical location of particular scallop beds and may cut a major scallop bed in two. This inadequacy of the statistics system was previously presented in Robert et al (1984). The separation of the fleets (1987 onward) at latitude 43^0 40' is adding another dimension to the inadequacy of the statitical reporting system. Lurcher Shoals have scallop beds spreading both north and south of latitude 43^0 40' so that scallop catches statistically compiled in NAFO sub-subarea 4Xq may still originate from the inshore and / or offshore fleets. One would have to assume that catches from vessels under 19.8 m come from the upper reaches of the Lurcher Shoals (north of the separation line) while vessels over 19.8 m fish German Bank and the lower Lurcher Shoals (south of the line).

All vessels (over 25.5 G.T. or 14 m L.O.A.) fishing the Scotian Shelf are required to keep logbooks in which daily fishing activities are recorded. Daily log records supply information on the catch and its location and fishing effort such as hours spent fishing, width of gear, and number of crew. Catch-rate estimates may be computed when complete effort data are provided with respect to the catch (Class 1 data). Total effort may be estimated according to the effort that generated the catch for which all information (location, hours fished, gear, etc.) is available. The productivity of a specific ground may also be established assuming that the catch with known location is representative of the total catch from that ground.

Scallop Fleets

Two components of the Canadian offshore fleet may drag for scallops on the Scotian Shelf. The deep-sea fleet, L.O.A. over 19.8 m is excluded from a 12 nautical miles zone near-shore and waters in the Bay of Fundy and approaches north of latitude 43^0 40' following the Inshore / Offshore Agreement. The Bay of Fundy fleet, mostly L.O.A. between 14 and 19.8 m (Bay of Fundy licensed vessels), has to restrict its activities on the Scotian Shelf to the upper parts of the Lurcher Shoals between latitudes 43^0 40' and 44^0 00' following the Agreement.

Despite the different size of vessels, both fleets use an offshore-type scallop drag which width may vary from 2.4 to 4.9 m (8-16 feet). The Bay of Fundy fleet fishes only one drag at a time while the deep-sea fleet fishes two drags simultaneously, one on each side. These are slightly wider than the ones used by the Bay of Fundy fleet. On occasion, a Bay of Fundy vessel may use a gang of Digby-type drags.

Catch Sampling

Catch sampling information is available for the deep-sea fleet only. Port coverage varies greatly, from none for southwest Nova Scotia ports like Yarmouth and Saulnierville to somewhat fair in the Lunenburg - Riverport area. However, since the exploitation of scallop grounds on the Scotian Shelf was somewhat irregular until very recently, sampling of the catch is rather sporadic and does not meet target levels to sample the catch adequately.

Survey Procedures on the Scotian Shelf

The catch distribution derived from log records for each particular fishing ground is used to randomly stratify survey stations. Catches from the deep-sea fleet over the year prior to the survey are considered. Annual surveys are carried out during May on a Government research vessel. Some exploratory tows were performed at the western end of Banquereau Bank around latitude 44^0 30' N., longitude 60^0 00' W. On Browns Bank, survey work was carried out on the northwest side where the Bay of Fundy fleet had reported some fishing activities in 1986. The near-absence of commercial size stocks in the German / Lurcher area precludes detectable levels of fishing activity. For the last two years, the annual stock survey has not been conducted here.

A 2.44 m wide New Bedford offshore dredge (75-mm ring size) lined with 38-mm stretch mesh polypropylene netting was the survey gear. Tows were of ten minutes duration; distance towed was determined either from Loran C bearings, start-end of tow, or from continuous recording via a desk-top computer. Catches were later standardised to a tow length of 800 m. For each tow, the following data were recorded: 1) shell heights in 5-mm intervals for all live scallops and cluckers (shells with both valves still attached at the hinge); 2) tow location with Loran C bearings; 3) depth (m); 4) compass bearing for direction of tow; 5) duration of tow in minutes; 6) substrate type; 7) count of the number of vertical rings covered by the catch; and 8) total scallop catch as a round weight.

Relevant Biological Information

Biological information dealing only with growth-rate and meat weight on shell height allometry are given here. Biological data has been gathered since 1982 as part of an on-going study of somatic and gonadal growth cycles.

Recently, areas such as Sable Island - Western Bank have better sampling coverage from the commercial fleet than the Browns Bank area where little fishing activity has taken place.

Samples from 1982 to 1986 surveys and samples collected from the fleet up to 1986 were used in the analysis. Table 1 presents variables of von Bertalanffy growth curves and the number of scallop shells that have been ring-read for each area. It also gives the regression parameters for estimating meat yield as a function of shell height and the number of animals examined. In an

attempt to reduce seasonal effects in yield conditions, samples collected at all times of the year have been included in the analysis to approximate a 'year round' value. Biological data for Banquereau Bank are presently borrowed from the neighboring Middle Grounds due to lack of specific data. Middle Grounds is in geographical proximity and has scallop beds in the same depth range and bottom types as Banquereau Bank. The Sable Island area presents a wide range of depths (20-over 100 m) where scallop concentrations occur, leading to a great deal of heterogeneity in growth patterns. However, all data were pooled together to generate one equation for the area.

RESULTS

Scallop Fleets

Previous to 1984, over 100 vessels from the deep-sea fleet and the Bay of Fundy fleet were exploiting scallop grounds on the Scotian Shelf (Table 2). This activity declined during 1984, 1985 to increase again in 1986. Following the Inshore / Offshore Agreement, the Bay of Fundy fleet was restricted to a very small section of the Shelf and only one vessel fished the area according to the information available. Once again, the deep-sea fleet activities declined in 1987, by 40 % from 1986 levels.

For both fleets, the Scotian Shelf fishery is not a feature as permanent as the Georges Bank fishery for the deep-sea fleet and the traditional scallop grounds within the Bay of Fundy for the Bay of Fundy fleet. With Georges Bank catch removals limited under an enterprise allocation system for the last two years the deep-sea fleet is shifting some of the traditional effort to scallop grounds on the Scotian Shelf in NAFO subareas 4V and 4W. Catch-rates in NAFO 4W are below average (especially compared to Georges Bank rates). Very low levels of abundance of commercial size stocks in the Bay of Fundy traditional fishing areas had forced the Bay of Fundy fleet to move away from the Bay itself to make numerous fishing trips to Georges Bank and the western Scotian Shelf. However, stocks are improving in the Bay and may limit the fleet's excursions outside the Bay.

To give methodical coverage to all fishing areas (Fig. 1) (from east to west), each area is looked at with respect to: a fishery profile, an estimate of its productivity in terms of distribution of scallop beds and abundance, catch sampling, and survey results.

Banquereau Bank

Historically speaking, Banquereau Bank (NAFO subarea 4V) has never been reported as a scallop-producing area, catches averaging less than 10 t per year (Table 3). It is a natural geographical extension of Sable Island Bank to the east. Highest landings (16 t) were reported in 1986; this coincided with the highest landing for the Sable Island area. But this trend could not be maintained according to the 1987 figure of under 1 t with a 50 % drop in CPUE. These catches have also originated from TMS (Ten Minute Square) on Banquereau Bank adjacent to Sable Island Bank. Catch levels and the profile of catch-rates thus far do not indicate the presence of an important stock biomass.

The 1987 Scotian Shelf stock survey had 5 exploratory tows on Banquereau (Table 4). Few scallops were caught, confined to age 5 + with a mode at age 6 (Table 5). Prerecruits were absent in the lined gear (Table 9).

Middle Ground

Middle Ground is a shallow bank of which 500 square nautical miles would have commercial densities of scallops. Its fishery characteristics are found in Table 6. Scallop production has been fairly sporadic with a 100 % increase in catches from 1985 to 1986 followed by a serious drop (52 to 7 t) in 1987. Catch-rates had been moderate at best, 0.5 kg/crhm in 1982, to decline gradually to 0.15 for the last two years. Figure 2 shows the gradual intensification of exploited grounds from 1980 on.

Sampling of the catch (Table 7) indicates that a wide range of meats are shucked (2 - 68 g) with a relatively large mean weight. This profile varies little between years although only a small number of meats are weighted.

Stock surveys (tables 4, 8-9) have shown low abundance of scallops at age except for the first survey in 1983. Lowest stock levels are recorded in 1987. There is only a modest sign of prerecruits in the lined gear. Consistently low stock levels rank Middle Ground as a marginal scallop fishing area.

Sable Island/Western Bank

When the deep-sea fleet began to fish scallop grounds in the Sable Island area in 1980, it confined itself to a small area of Western Bank, at the edge of the continental shelf within the 100-m isobath (Fig. 2). Gradually, fishing activities extended their range not only along the edge of the shelf (in a northeasterly direction) but also over Western Bank, Sable Island Bank, and in the immediate vicinity of Sable Island up to Banquereau Bank (NAFO sub sub-areas 4Wf, g, h, j, l, and u designated here under the label of SA 4Wf-j). Annual catches have been low (Table 6) until 1986 (1983 excepted) when a sharp, 10 times increase occurred from 1985 to 1986. High 1986 catches correspond to the highest effort values observed. The 1987 catch figure is relatively high with about 2.5 million crhm for total effort. Catch-rate values have always been low. Despite the extremely high effort expended in 1986, CPUE had dropped by about 25 % and maintained itself in 1987. It appears that exploitation of all available scallop grounds including more distant ones contribute to sustain catch-rates although at a low level.

Except for 1985, the mean weight of scallop meats shucked has been considerably smaller than in neighboring Middle Grounds, (Table 7) 12 versus 20+ g. The 1987 catch sampling recorded the smallest and largest shucked scallop since the fishery began in 1980 (2 - 98 g). About 50 % of the catch was scallops between 7 and 10 years of age, a fair mix of year-classes but the growth pattern of this area is complex. Scallop concentrations are dispersed over such a wide area that they encounter quite a diversity of environmental conditions and habitats.

The significant aggregations of juveniles observed during the 1985 survey were somewhat resampled in 1987 as indicated by the resurgence of numbers-at-age (Tables 9 - 11) for this group. Geographical coverage of the 1987 survey was more extensive compared to the previous year. 1986 survey results were a bit odd as outlined in Robert et al (1987a). Weighted average numbers-at-age per tow plotted for the last 4 annual surveys (Fig. 3) show the modal progression of the pulse of young scallops. Large size scallops are kept at low levels by the fishing pressure.

Figure 4 profiles the 1982 year-class distribution and abundance with shaded contours from 1984 to 1987 (ages 2-5); the darker the shade, the more abundant scallops were in that particular area. According to the modal size distribution of the present stock (Fig. 3), the 1982 year-class would be relatively stronger than any other class and could contribute significantly to the fishable biomass. Concentrations of juveniles are highly aggregated in 1984 at the somewhat low number of sampling stations (40). Survey gear efficiency is also low for age 2 scallops. The pre-recruits picture in 1985 shows the locations with high numbers better, although the area sampled is still limited. With 1986, sampling extended geographically but did not necessarily overlap with previous years; another possible high concentration was identified to the north of the ones already located. The 1985 and 1987 plots have the same levels of shaded contours with the 1987 survey covering a broader area; at age 5, the year-class is starting to diffuse, likely due to fishing activity. It is nevertheless possible to follow up the distribution and abundance levels of the 1982 year-class for 4 consecutive years despite a fairly restricted spatial distribution of the highest densities.

Browns Bank/Tusket Area

When commercially important, scallop aggregations are found along the southern edge of Browns Bank (NAFO sub-subarea 4Xp) around the 100-m isobath and on the northern side of the Bank (Tusket, NAFO sub-subarea 4Xo) but in much deeper waters.

These scallop beds used to be exploited by both fleets, the deep-sea fleet landing more than the Bay of Fundy fleet except in 1986; Table 12 has data for the deep-sea fleet. Despite

discrepancies between statistical landings and logged catches, the scallop production from the Browns Bank area has decreased erratically; the same may be said for catch-rates until 1985. From then on, the deep-sea fleet CPUE shows a modest recovery while the Bay of Fundy fleet CPUE rises sharply. However, these last values may be non-representative. Figure 5 maps the productivity on a TMS basis. No landing nor logged catches have been reported for 1987.

The meat weight distribution in the catch (Table 13) varies greatly on an annual basis but the percentage examined is too small to draw any conclusion. Browns Bank catches have not been sampled in 1985 - 1987.

Survey characteristics are given in Tables 14-16. Previous surveys had found high concentrations of juveniles in a well delimited area of southeastern Browns Bank. However, these year-classes will not contribute to a fishery revival. Very heavy mortality rates appear to have been experienced by possibly 3 successive year-classes of scallops on the southern edge of Browns Bank (Robert et al 1986). Both the 1986 and 1987 surveys established the paucity of pre-recruits and recruits. The stock will remain in a somewhat collapsed state due to the massive disappearance of year-classes at the juvenile stage, the lack of older animals in any quantity and the absence of prerecruits during the last two surveys.

German Bank/Lurcher Shoals and the Outer Reaches of the Bay of Fundy

NAFO sub-subarea 4Xq includes German Bank and the lower half of the Lurcher Shoals (up to latitude 44 degrees North); the upper half of Lurcher Shoals is part of sub-subarea 4Xr. Statistical landings and logged catches for both fleets (Tables 17 and 18) diverge for these respective areas illustrating the misrepresentation resulting from the statistical areas boundaries as presently set. Biological differences exist between German Bank and Lurcher Shoals; growth-rate being slower on German Bank relative to Lurcher Shoals and the outer reaches of the Bay of Fundy.

During the recent exploitation of this area, the amount of fishable stocks steadily declined from its initial levels until 1985 (Table 17). Catch-rates were also following the same trends. A slight reversal of the downward trend appears to take place in 1986. The deep-sea fleet landed under 2 t. ; the Bay of Fundy fleet took relatively small quantities but at catch-rates similar to the high values encountered in 1979. In 1987 it conducted only one fishing trip landing less than 1 t of meats at moderate catch-rates (7 kg/hm). At certain times the production of Lurcher Shoals has been comparable to the production of some TMS on Georges Bank (Fig. 5). Sampling of the catch (Table 18) has been scanty or did not take place.

The last survey results had indicated the presence of large old scallops and that their abundance was declining. Very low levels of fishing activity took place from 1985 onward. The annual stock survey did not extend to the German/Lurcher area in 1986 and 1987.

Exploitation of scallop grounds in the outer reaches of the Bay of Fundy has been decreasing after the landing pulse of the early 1980s (Table 19). Catch-rates have behaved similarly. Landings by both the Bay of Fundy and the deep-sea fleets had been minimal in 1986. However the deep-sea fleet managed a catch-rate (0.458 kg/crhm) comparable to values obtained during the initial stages of the recent fishery of these scallop beds. The Bay of Fundy fleet, the only fleet entitled to the area in 1987, did not exploit these beds.

Southwest Bank

The deeper waters of NAFO subarea 5Yb are exploited on occasions although level of catches have not been significant. Small (less than 14 m) vessels from Grand Manan Island expend the most effort in this statistical area. (See Robert et al (1987b) for the latest evaluation).

DISCUSSION and CONCLUSION

Short term Outlook

The formal separation of the fleets with respect to access to fishing grounds has not modified the traditional fishing patterns of either fleet since its inception at the beginning of 1987. The near-absence of commercial size stocks on German Bank and the Lurcher Shoals enticed little fishing effort. The remainder of scallop beds (outside of the Bay of Fundy) in NAFO subarea 4X, on Browns Bank have experienced successive recruitment failures as documented through recent annual stock surveys so it is doubtful that Browns Bank would attract a great deal of fishing activity in the near future. Scallop beds in NAFO subarea 4W however have been sustaining low to moderate exploitation since 1980. The stock structure and abundance levels of Western Bank and grounds in the Sable Island area indicate that recruitment is taking place on a regular basis. Although quantities being caught are not comparable to Georges Bank, they still offer considerable potential to the deep-sea fleet in its current situation.

Long Term Productivity

Since the development of the offshore scallop fishery, there has been only 3 periods when scallop beds in the German / Lurcher area have been exploited commercially. As early as 1947 the existence of profitable grounds in the Lurcher Shoals area was known since fishing regulations were changed to allow summer fishing in the 'lower Bay of Fundy'. Some Digby-based vessels used the privilege that summer (Bourne 1964). The Annual Report of the Saint Andrews Biological Station (Anon 1963) further comments on a few vessels that would have made 1 - 2 trips to the Lurcher in 1962. Unfortunately, details on the fishery performance were not found. From then on, small-scale landings, under 25 t, were recorded for a few years until 1979 when significant catch levels were reached for five consecutive years before being phased out again (Fig. 6). At times, total annual catch on a Ten Minute Square basis for some TMS on the Lurcher Shoals was of the same order of magnitude as TMS on the productive northern edge of Geroges Bank. Biological characteristics of the stocks most recently exploited showed that there had been one main recruitment event; that the growth-rate was moderate to slow and that the fishery relied on the accumulated biomass of older, large scallops, small animals not being encountered either in the commercial fishery or research stock surveys. If history has any inference on the future, it would appear that scallop stocks do not show up on a regular basis and would not sustain continuous fishing. Browns Bank has always been a stopover on the way to Georges Bank for a vast majority of the deep-sea fleet. The existence of small scallop beds has been known for some time and has contributed significantly to the fishery during certain years (Fig. 6). The documented history of the stock (Robert et al 1986) notes the possibility of recruitment failures, the slowest growth-rate of all the stocks available to the fleet, and poor meat yields. At times, high density levels could generate enough interest, but only in an opportunistic fashion.

Exploratory work started early in NAFO subarea 4W. In 1945, the "Mary E. Kenney" explored Middle Grounds and Sable Island Bank but did not find extensive beds (Bourne 1964). Then in 1953, more vessels gave greater coverage to the same areas and discovered a few beds worthy of mention but no large scale operation took place. Brief incursions happened in 1969 - 70 (100+ t). The next important annual landed figure refers to 1980 which started the present exploitation trend (Fig. 6). Contrary to NAFO subarea 4X grounds, the size distribution of these stocks is mixed and research stock surveys have localised aggregations of juveniles. Depending on location and depth, growth-rate may be quite good. Meat yields are excellent in the upper depth range. Although the information currently available does not suggest that the stock levels could equal Georges Bank density levels nor catch-rates performance of the fishery there, it is possible that NAFO subarea 4W fishing grounds could sustain light to moderate exploitation.

Although historical catches could be averaged to provide a long term mean, it is somewhat pointless due to the extremely wide range of values. For example, during the time period 1967-86, the Sable Island / Western Bank area was not exploited at all 8 years out of 20. When fishing took place, annual catches ranged from 0.6 t. in 1981 to 618.4 t. in 1986 (mean = 104.0 t., s.d. = 169.7).

In addition to establishing long term productivity by previous catches and historical fishery performance, one could examine research survey results to derive biomass estimates. Only a short history of research survey results for these areas and the aggregative nature of scallop beds preclude such derivation.

One could argue that exploitation of scallop stocks is not a true indicator of their presence at commercial densities and that fishery performance is not directly related to stock abundance, some grounds being available but left unfished. In the case of scallops, a high landed value has been stimulating expioratory work from the fishing industry since the beginning of the offshore fishery, some 30 years ago. More recently, competition for access to fishing grounds has emphasised the exploitation of all known beds, even in areas quite distant from home ports like St. Pierre Bank for fleets based in southwest Nova Scotia. It is considered doubtful that, nowadays, large scallop aggregations at commercial densities would remain to be discovered on the Scotian Shelf.

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Table 1.- Updated biological data on growth-rate and meat yield (year round values) for scallop fishing grounds on the Scotian Shelf. N = number of scallops examined.

	Growth	Yield
Middle Grounds and Banquereau Bank	N = 417	N = 289
	H_∞ = 161.504mm	intercept = -10.752
	t_0 = 1.3360	slope = 2.890
	k = 0.1851	
Sable, Western Bank	N = 2,048	N = 2,052
	H_∞ = 140.075mm	intercept = -11.451
	t_0 = 1.2981	slope = 2.997
	k = 0.2133	
Browns Bank	N = 398	N = 420
	H_∞ = 114.046mm	intercept = -16.265
	t_0 = 1.3456	slope = 3.997
	k = 0.2636	

Table 2.- Number of vessels by fleet fishing scallop grounds on the Scotian Shelf as per log information.

Year	Bay of Fundy under 19.8m L.O.A.	Deep-sea over 19.8m L.O.A.	Total
1979	38	75	113
1980	37	75	112
1981	44	76	120
1982	45	75	120
1983	27	73	100
1984	29	50	79
1985	14	34	48
1986	32	55	87
1987	1	33	34

Table 3.- Fishery characteristics for the Banquereau Bank area (NAFO 4V) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertaining to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1980	3.30	7.17	7.17	20,171	0.355
1981	0.00	0.00	--	--	--
1982	0.69	0.42	0.42	1,092	0.387
1983	5.37	3.26	3.26	7,343	0.444
1984	3.18	0.63	0.63	939	0.672
1985	0.24	N/A	N/A	N/A	N/A
1986	15.64	11.15	10.98	45,849	0.239
1987	0.65	0.51	0.51	4,617	0.110

Table 4.- Number of survey stations in NAFO SA 4V and 4W by year and by stratum type.

Middle Grounds	1983	1984	1985	1986	1987
low catch	4	8	5	4	6
medium	4	-	-	-	-
high	12	12	5	6	6
total	20	20	10	10	12

Sable/Western Bank	1983	1984	1985	1986	1987
low catch	N/A	14	7	13	5
medium	N/A	13	25	42	27
high	N/A	13	8	10	58
exploratory	N/A	-	-	10	-
total		40	40	75	90

Banquereau Bank	1987
exploratory	5
total	5

Table 5.- Average number of scallops at age caught in a lined 2.44m New Bedford offshore dredge, in the western section of Banquereau Bank.

	Age (years)										Mean	s.d.
	1	2	3	4	5	6	7	8	9	10+		
1987 stock survey												
exploratory	0	0	0	0	1	9	4	1	1	1	18	25

Table 6.- Fishery characteristics for the Middle Grounds area (NAFO 4We) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertaining to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1979	-	-	-	-	-
1980	3.65	1.42	1.42	5,434	0.262
1981	-	-	-	-	-
1982	72.39	62.09	61.12	122,106	0.501
1983	105.16	104.92	100.59	309,055	0.325
1984	11.90	9.94	8.34	47,585	0.175
1985	26.89	21.59	21.59	99,345	0.217
1986	51.27	51.28	50.46	345,552	0.146
1987	6.70	7.03	6.64	44,274	0.150
		Fishery characteristics for Sable Island and Western Bank (NAFO 4Wf-j)			
1979	-	-	-	-	-
1980	60.99	50.48	50.48	219,987	0.229
1981	0.56	0.00	0.00	0	-
1982	64.10	61.40	61.40	243,779	0.252
1983	185.15	166.47	164.45	886,072	0.186
1984	71.30	64.65	63.58	370,231	0.172
1985	64.93	76.00	76.00	294,217	0.258
1986	618.35	585.26	551.88	3,070,138	0.180
1987	415.80	412.01	394.23	2,339,915	0.168

Table 7.- Nature of the catch from NAFO SA 4W determined by the analysis of scallop meat weights.

	% catch examined	meat weight (g)				n meats
	catch landed	mean	min	max	s.d.	
Middle Grounds						
1983	0.0240	20.00	3.04	69.99	0.13	1259
1984	0.0392	14.84	4.23	46.97	0.14	314
1985	0.0175	22.88	6.31	66.40	0.22	217
1986	0.0134	22.73	4.33	61.51	0.23	302
1987	0.0436	21.48	2.34	68.23	0.30	137
Sable Island/Western Bank						
1980	0.0133	9.46	3.87	22.11	0.04	860
1981	-	-	-	-	-	-
1982	0.0015	9.15	4.65	15.38	0.11	102
1983	0.0339	13.49	2.25	72.43	0.04	4658
1984	0.0161	11.10	2.65	42.48	0.07	1034
1985	0.0025	27.41	11.27	54.30	0.52	62
1986	0.0271	15.03	2.33	79.13	0.03	11397
1987	0.0319	14.35	2.22	98.14	0.04	9226

Table 8.- Average number of scallops at age caught in a lined 2.44m New Bedford offshore dredge, Middle Grounds.

	Age (years)										Mean	s.d.
	1	2	3	4	5	6	7	8	9	10+		
1983 stock survey												
low	0	0	0	0	1	0	0	0	0	0	2	2
medium	0	0	0	2	13	8	1	0	0	2	26	15
high	0	0	0	3	31	9	0	0	0	1	55	67
1984 stock survey												
low	0	0	0	0	2	1	2	1	0	0	8	10
high	0	0	0	0	2	6	4	2	1	2	17	16
1985 stock survey												
low	0	0	0	3	6	2	4	1	0	0	20	23
high	0	0	0	0	0	0	3	3	0	1	10	13
1986 stock survey												
low	0	0	0	0	0	0	0	1	1	3	7	7
high	0	0	0	1	0	3	6	4	2	2	17	10
1987 stock survey												
low	0	0	2	0	1	1	0	0	1	2	6	8
high	0	0	0	0	0	0	1	1	0	3	6	4

Table 9.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum, Middle Grounds area.

	Age (years)		
	1-4	5-10	11+
1983 stock survey			
low	0	1	0
medium	2	23	1
high	3	40	1
1984 stock survey			
low	0	6	0
high	0	16	1
1985 stock survey			
low	3	13	0
high	0	6	1
1986 stock survey			
low	0	4	1
high	1	16	1
1987 stock survey			
low	2	4	1
high	0	3	2
Banquereau Bank			
1987 stock survey			
exploratory	0	16	1

Table 10.- Average number of scallops at age caught in a lined 2.44m New Bedford offshore dredge, Sable Island - Western Bank area.

	Age (years)										Mean	s.d.
	1	2	3	4	5	6	7	8	9	10+		
1984 stock survey												
low	0	4	2	4	5	3	3	1	1	5	28	39
medium	1	22	6	3	8	6	4	1	1	4	60	63
high	0	5	5	6	10	9	3	3	2	3	46	39
1985 stock survey												
low	0	71	55	27	15	12	7	6	2	9	205	222
medium	0	9	15	16	7	6	6	5	2	7	74	59
high	1	59	112	40	33	24	6	4	2	0	281	181
1986 stock survey												
low	0	1	3	2	2	1	0	1	1	5	15	15
medium	0	2	2	4	2	2	1	1	1	6	20	30
high	0	1	0	1	1	1	1	2	2	6	13	9
exploratory	0	0	0	0	0	0	0	0	0	1	3	2
1987 stock survey												
low	0	0	1	2	2	1	1	1	1	5	14	12
medium	0	2	4	6	9	6	2	1	1	6	37	51
high	0	12	23	35	34	16	5	3	2	5	134	149

Table 11.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum, Sable Island - Western Bank area.

	Age (years)		
	1-4	5-10	11+
1984 stock survey			
low	10	14	4
medium	32	21	3
high	16	28	2
1985 stock survey			
low	153	43	8
medium	40	27	6
high	212	69	0
1986 stock survey			
low	6	5	5
medium	8	8	5
high	2	8	5
exploratory	0	0	1
1987 stock survey			
low	3	6	5
medium	12	20	5
high	70	61	4

Table 12.- Fishery characteristics for the Browns Bank - Tusket area (NAFO 4Xp and 4Xo) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertaining to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
4Xo					
1979	0.00	13.70	13.70	21,964	0.624
1980	13.17	40.79	33.41	60,979	0.548
1981	0.36	1.40	1.40	2,219	0.632
1982	47.55	70.87	65.76	86,204	0.763
1983	42.70	53.11	44.96	78,613	0.572
1984	10.57	13.24	13.24	45,619	0.290
1985	0.00	0.84	0.84	2,155	0.389
1986	0.00	0.00	0.00	0	-
1987	0.00	0.00	0.00	0	-
4Xp					
1979	73.05	77.90	76.62	145,118	0.528
1980	258.23	205.91	199.25	479,388	0.416
1981	24.98	12.86	12.65	19,578	0.646
1982	114.07	83.40	82.84	217,580	0.381
1983	63.32	34.83	33.46	135,526	0.247
1984	16.60	4.95	4.95	26,565	0.186
1985	6.93	15.54	15.54	36,413	0.427
1986	4.64	4.00	4.00	6,948	0.576
1987	0.00	0.00	0.00	0	-

Table 13.- Nature of the catch from Browns Bank/Tusket area determined by the analysis of scallop meat weights.

	% catch examined	meat weight (g)			
	catch landed	mean	min	max	s.d.
1979	0.0022	16.29	4.01	58.66	0.18
1980	0.0195	10.54	1.37	87.46	0.04
1981	0.0080	35.75	13.71	55.37	0.35
1982	0.0020	16.39	2.90	47.13	0.18
1983	0.0000	-	-	-	-
1984	0.0062	21.98	6.46	68.63	0.51
1985	0.0000	-	-	-	-
1986	0.0000	-	-	-	-
1987	0.0000	-	-	-	-

Table 14.- Number of survey stations on both sides of Browns Bank ,NAFO Sa 4Xp to the south, NAFO Sa 4Xo to the north by year and by stratum types.

	1983	1984	1985	1986	1987
low catch	16	2	2	4	-
medium	-	7	14*	14*	16*
high	18	10	8	1	-
total	34	19	24	19	16

*exploratory

Table 15.- Average number of scallops at age caught in a lined 2.44m New Bedford offshore dredge, Browns Bank/Tusket area.

	Age (years)										Mean	s.d.
	1	2	3	4	5	6	7	8	9	10+		
1983 stock survey												
low	46	368	2	0	1	1	1	1	1	2	676	1068
high	59	248	1	0	0	0	1	2	3	10	416	969
1984 stock survey												
low	0	0	0	0	0	0	0	0	0	0	0	--
medium	3	94	53	6	3	0	0	2	3	14	209	280
high	3	58	0	0	0	6	12	9	4	4	118	184
1985 stock survey												
exploratory	3	244	0	0	0	0	0	1	2	14	286	328
low	0	0	0	0	0	0	0	0	0	0	1	0
high	0	1	0	0	0	0	0	0	0	2	6	6
1986 stock survey												
exploratory	0	1	0	0	0	1	3	2	1	5	15	14
low	0	0	0	0	0	0	0	0	0	1	5	0
high	0	0	0	1	0	0	0	0	0	1	2	0
1987 stock survey												
exploratory	2	9	1	0	0	0	0	0	1	3	24	37

Table 16.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum.

	Age (years)		
	1-4	5-10	11+
Browns Bank / Tusket 1983			
low	416	6	1
high	308	9	7
Browns Bank / Tusket 1984			
low	0	0	0
medium	156	11	11
high	61	34	1
Browns Bank / Tusket 1985			
exploratory	247	6	11
low	0	0	0
high	1	0	2
Browns Bank / Tusket 1986			
exploratory	1	8	4
low	0	0	1
high	1	0	1
Browns Bank / Tusket 1987			
exploratory	12	2	2

Table 17.- Fishery characteristics for the German Bank/Lurcher Shoals area (NAFO 4Xq) for both fleets. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertaining to Class 1 catch only. (In parenthesis, catches supported by sales slips only.)

Bay of Fundy fleet Year	Landings	Logged catches	Class 1 catch	Effort (hm)	CPUE (kg/hm)
1979	293.82	258.25	182.37	7,112	25.64
1980	113.72	89.91	65.96	6,485	10.17
1981	194.73	185.51 (46)	125.57	14,352	8.75
1982	99.06	119.11 (16)	78.11	12,348	6.33
1983	43.68	32.30 (6)	16.76	5,949	2.82
1984	11.07	32.90	25.29	7,660	3.30
1985	2.80	1.45	0.30	416	0.71
1986	23.94	34.62	22.41	1,085	20.66
1987	0.66	0.41	0.41	57	7.09

Deep-sea fleet Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1979	102.32	147.10	145.20	157,729	0.921
1980	1269.71	1132.69	1021.86	1,614,441	0.633
1981	379.69	207.63	188.78	318,221	0.593
1982	659.74	535.84	403.51	954,628	0.423
1983	587.76	465.88	420.45	1,092,569	0.385
1984	207.13	175.83	156.45	581,969	0.269
1985	33.76	16.60	15.91	46,295	0.344
1986	1.59	0.00	0.00	0	-
1987	0.00	0.00	0.00	0	-

Table 18.- Nature of the catch from German Bank/Lurcher Shoals area determined by the analysis of scallop meat weights.

	% catch examined	meat weight (g)			
	catch landed	mean	min	max	s.d.
1979	0.0019	11.39	4.74	34.15	0.06
1980	0.0135	11.66	2.20	85.82	0.02
1981	0.0084	12.74	2.34	75.27	0.04
1982	0.0171	16.04	3.69	76.92	0.03
1983	0.0010	11.99	3.35	44.13	0.11
1984	0.0008	22.69	3.88	53.52	0.42
1985	0.0000	-	-	-	-
1986	0.0000	-	-	-	-
1987	0.0000	-	-	-	-

Table 19.- Fishery characteristics for the outer reaches of the Bay of Fundy (NAFO 4Xr) for both fleets. It is not possible to estimate landings from the Bay of Fundy fleet from this area; 4Xr statistical landings also include the traditional fishing grounds off Digby. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertaining to Class 1 catch only.

Bay of Fundy fleet Year	Logged catches	Class 1 catch	Effort (hm)	CPUE (kg/hm)
1979	0.05	0.05	11	4.72
1980	135.31	119.05	9,881	12.05
1981	179.23	174.71	16,416	10.64
1982	161.25	155.06	20,626	7.52
1983	35.24	30.86	6,011	5.13
1984	2490	23.96	7,674	3.12
1985	9.71	9.61	2,814	3.42
1986	2.11	2.11	1,771	1.19
1987	0.00	0.00	0	-

Deep-sea fleet Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1979	-	-	-	-	-
1980	16.86	65.63	60.91	126,700	0.481
1981	2.53	47.59	44.37	111,596	0.398
1982	0.03	87.44	58.66	154,694	0.379
1983	13.02	83.76	70.26	205,023	0.343
1984	4.55	24.35	20.11	98,465	0.204
1985	1.48	5.73	4.08	16,702	0.244
1986	0.00	2.79	2.79	6,092	0.458
1987	0.00	0.00	0.00	0	-

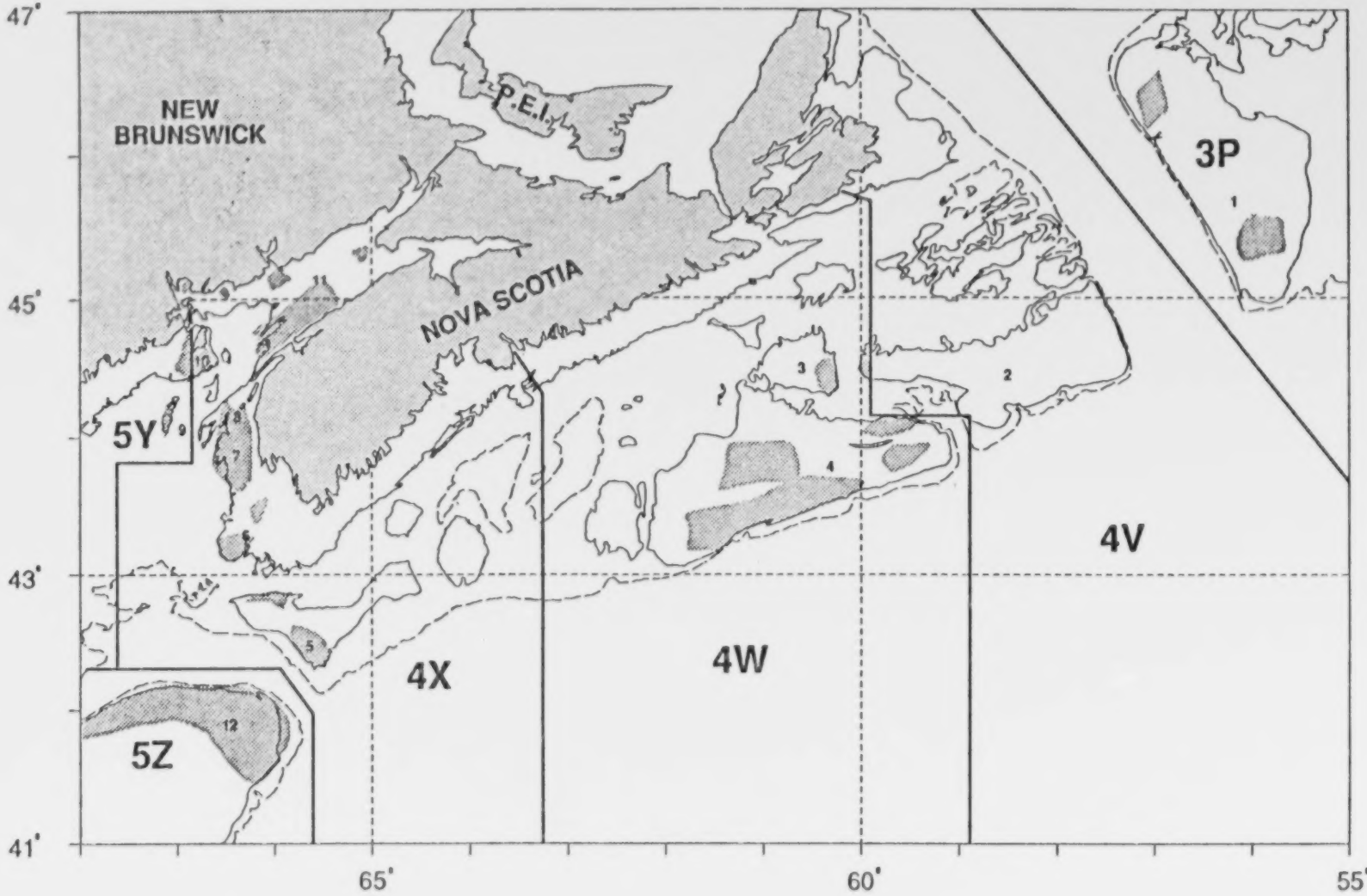
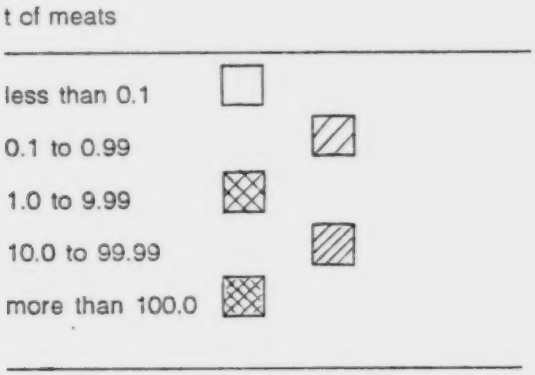
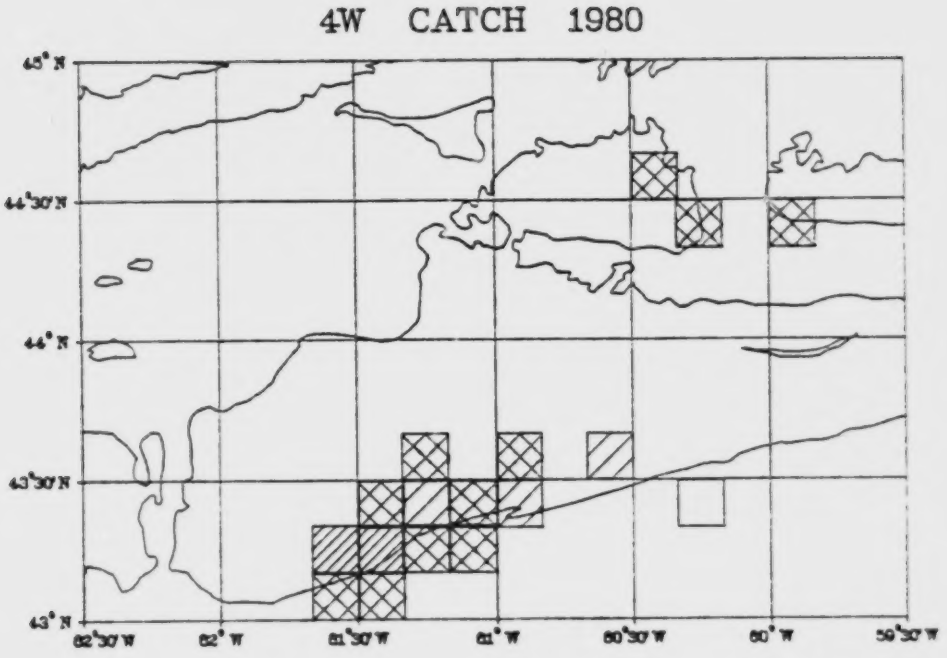


Figure 1.- Scallop fishing areas on the Scotian Shelf and St.Pierre Bank. The 100 and 200-m isobaths are represented. Areas in numerical order are: (1) St.Pierre Bank; (2) Banquereau Bank; (3) Middle Ground; (4) Sable Island area; (5) Browns Bank; (6) German Bank; (7) Lurcher Shoals; (8) Outer reaches of the Bay of Fundy; (9) Southwest Bank; (10) Grand Manan area and (11) the Bay of Fundy area. Georges Bank is also shown.

Figure 2.- Productivity of scallop fishing grounds in NAFO SA 4W on a ten-minute square basis (TMS) according to the convention illustrated below. The 100-m isobath is illustrated.

Figure 5.- Productivity of scallop fishing grounds in NAFO SA 4X on a TMS square basis according to the following convention:




4W CATCH 1980
45° N
44°30' N
44° N
43°30' N
43° N
62°30' W
62° W
61°30' W
61° W
60°30' W
60° W
59°30' W

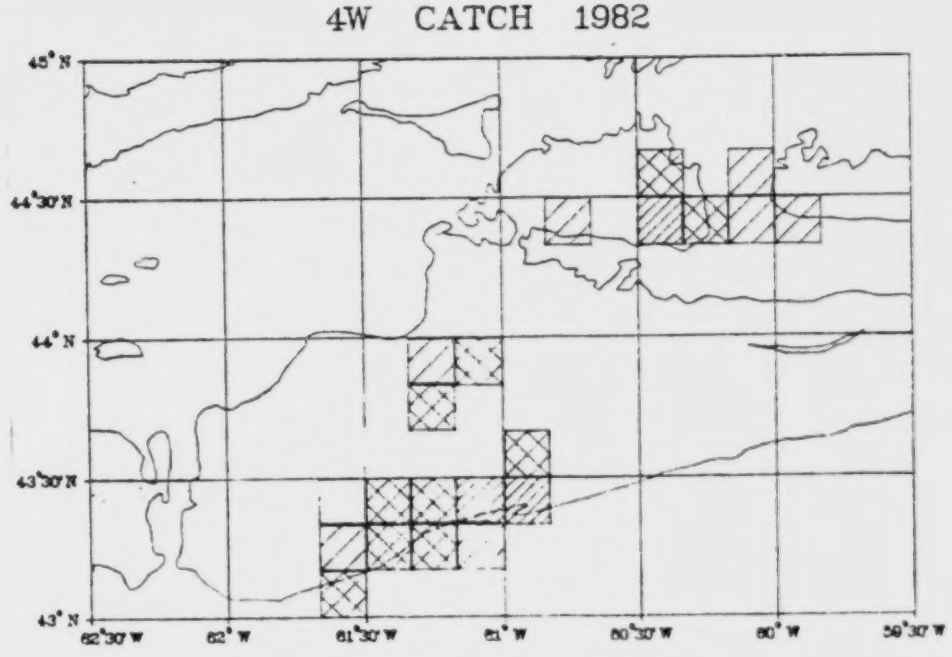
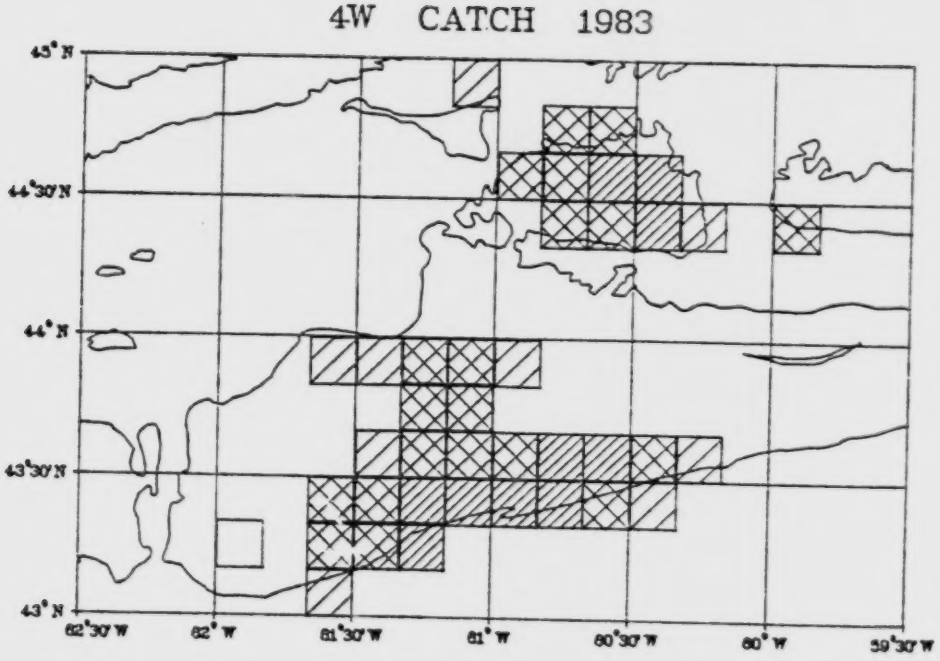

4W CATCH 1982
45° N
44°30' N
44° N
43°30' N
43° N
62°30' W
62° W
61°30' W
61° W
60°30' W
60° W
59°30' W

Figure 2.


4W CATCH 1983
45° N
44°30' N
44° N
43°30' N
43° N
62°30' W
62° W
61°30' W
61° W
60°30' W
60° W
59°30' W

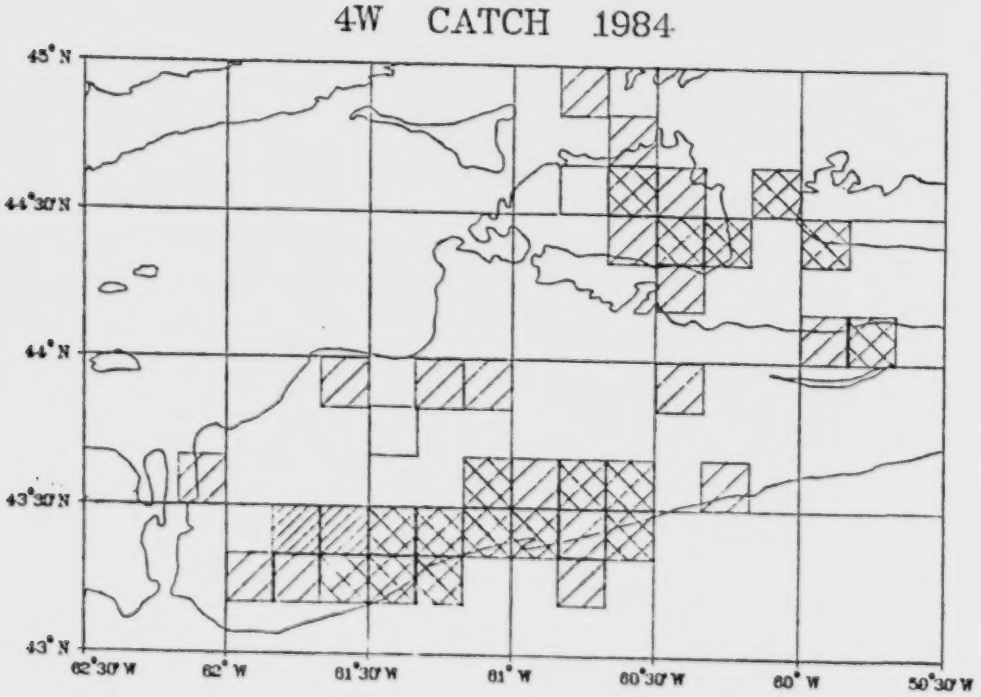
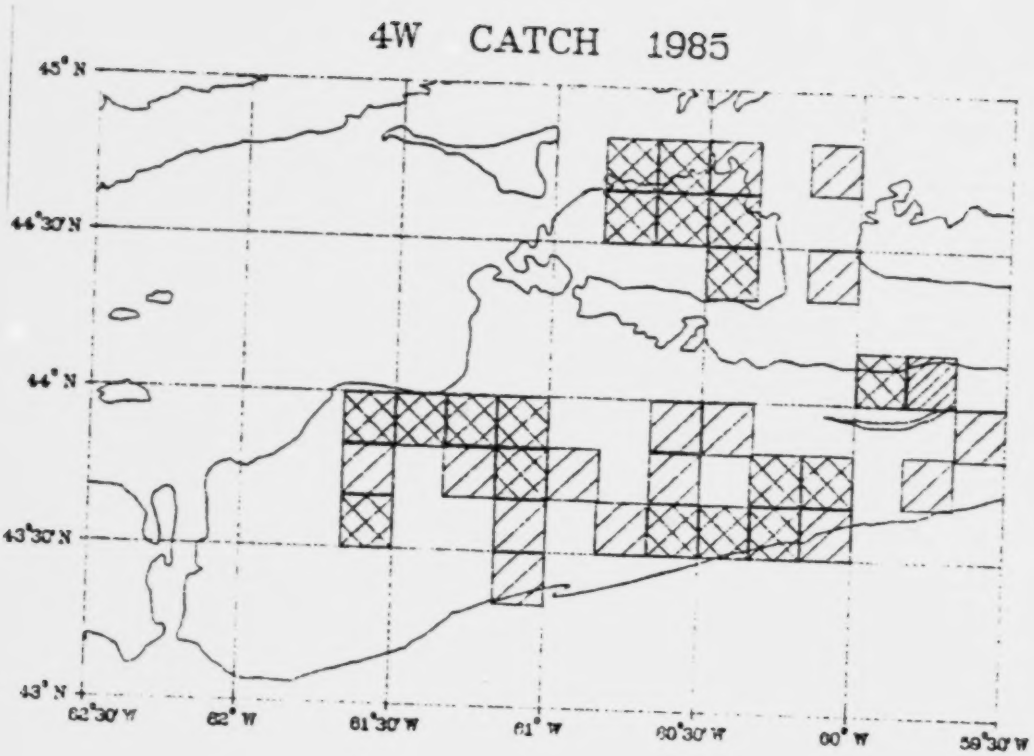

4W CATCH 1984
45° N
44°30' N
44° N
43°30' N
43° N
62°30' W
62° W
61°30' W
61° W
60°30' W
60° W
50°30' W

Figure 2.


4W CATCH 1985
45° N
44°30' N
44° N
43°30' N
43° N
62°30' W
62° W
61°30' W
61° W
60°30' W
60° W
59°30' W

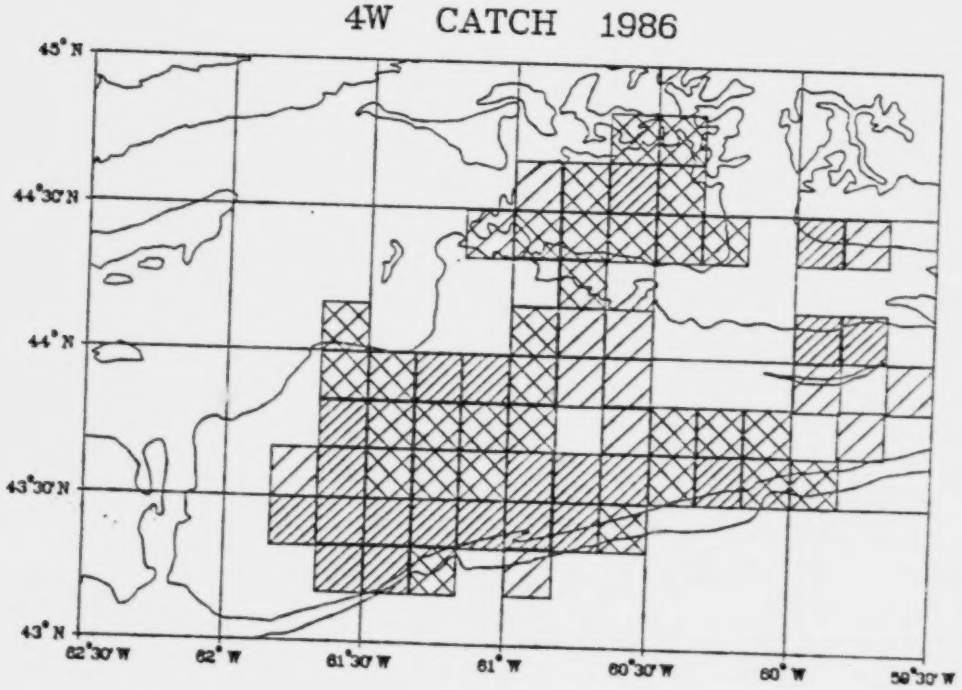

4W CATCH 1986
45° N
44°30' N
44° N
43°30' N
43° N
62°30' W
62° W
61°30' W
61° W
60°30' W
60° W
59°30' W

Figure 2.

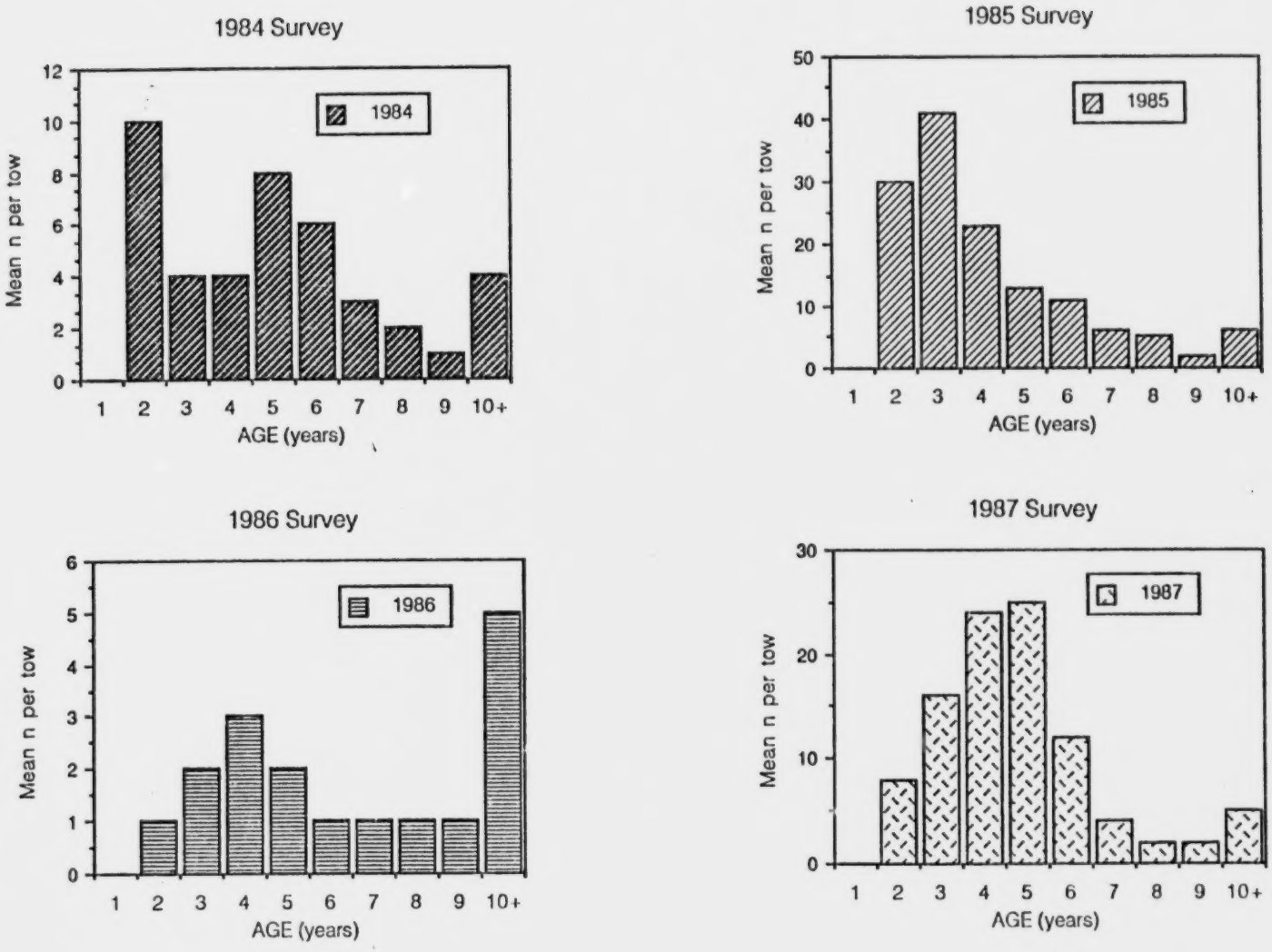


Figure 3.- Age frequency distribution. Total weighted average per tow for the 1984 to 1987 stock surveys of the Sable Island - Western Bank area.

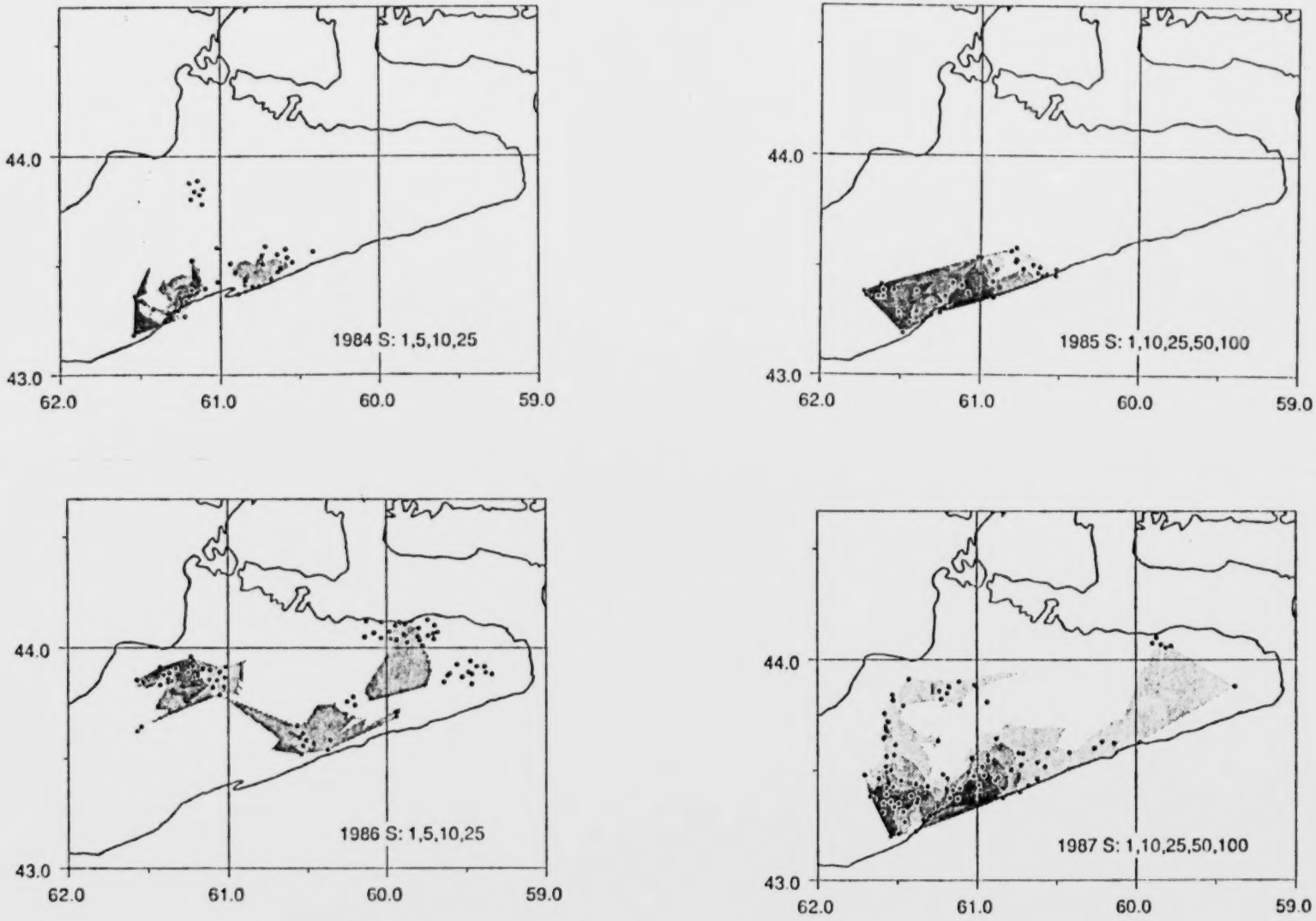
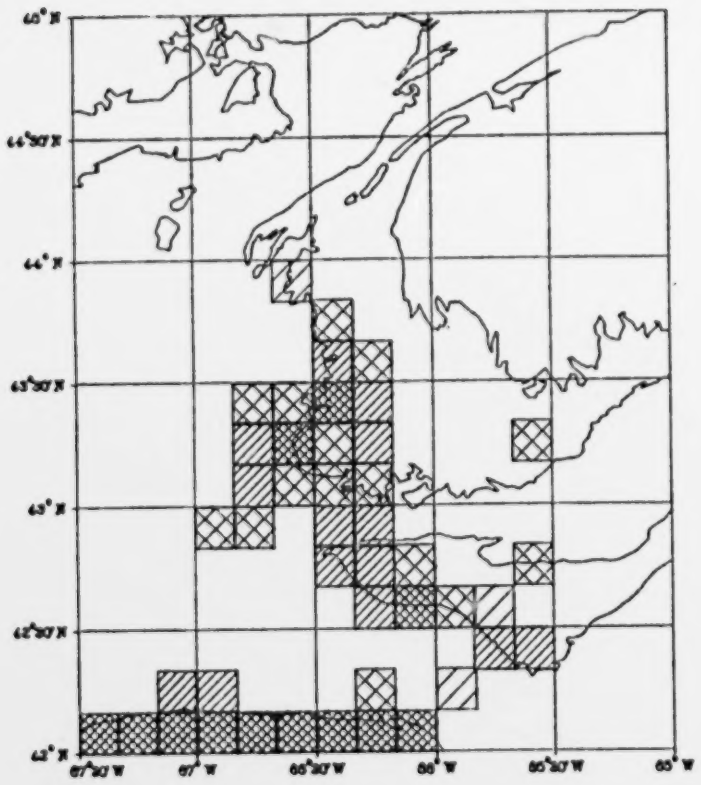


Figure 4.-Profile of the distribution and abundance levels of the 1982 year class over 4 consecutive annual stock surveys. The shaded contour gradients (refer to S on each plot) reflect number of scallops per standard tow.

4X CATCH 1979



4X CATCH 1980

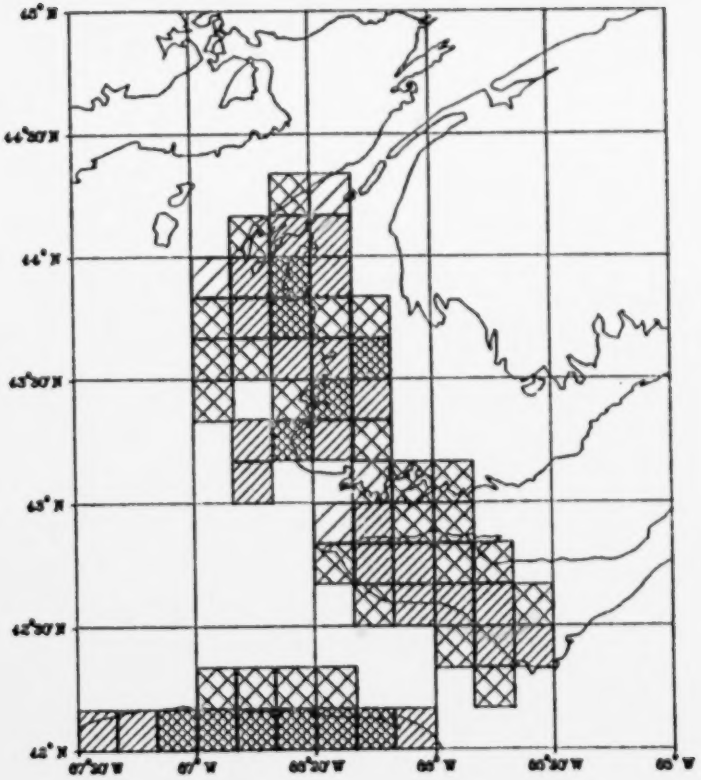


Figure 5.

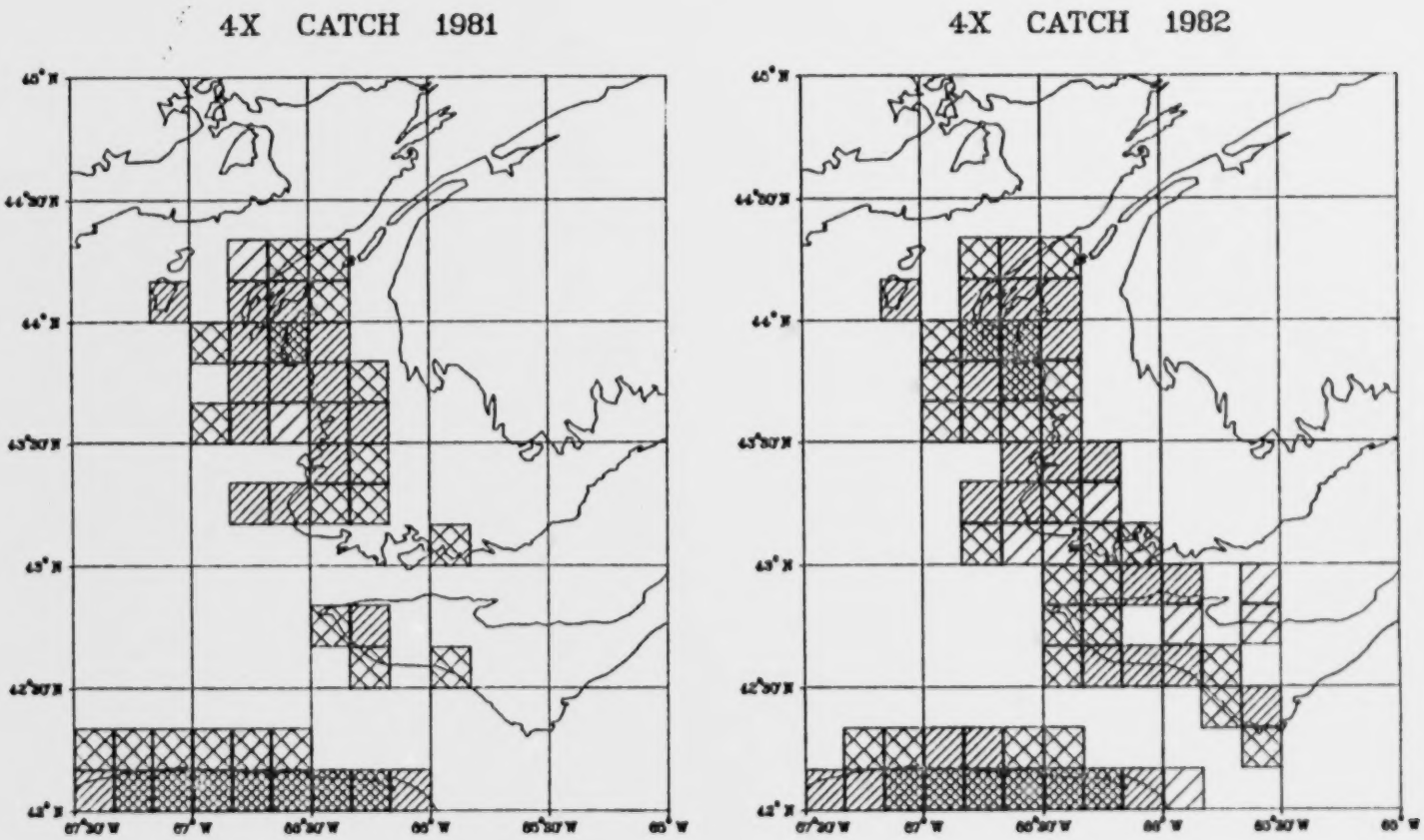


Figure 5.

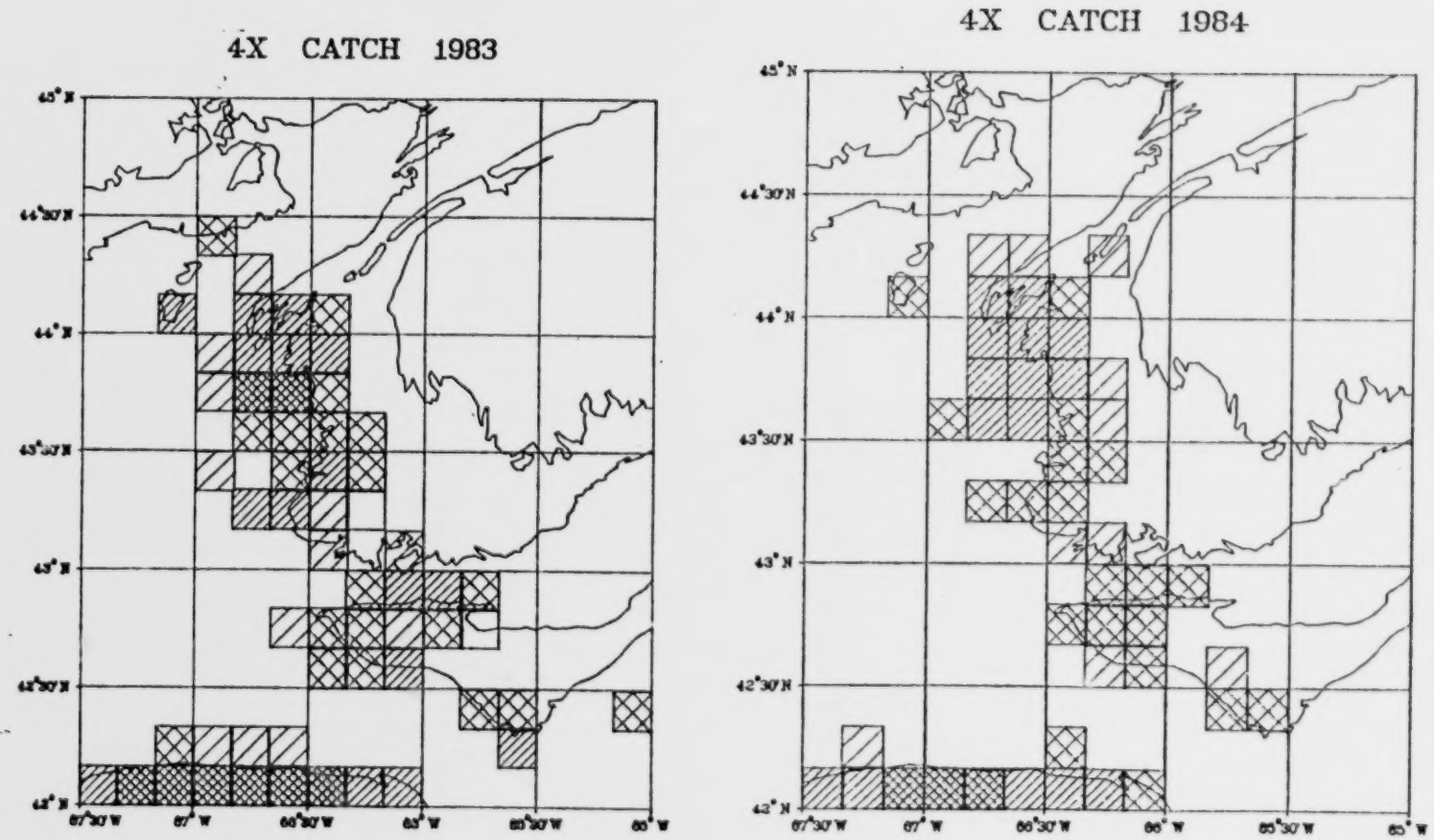
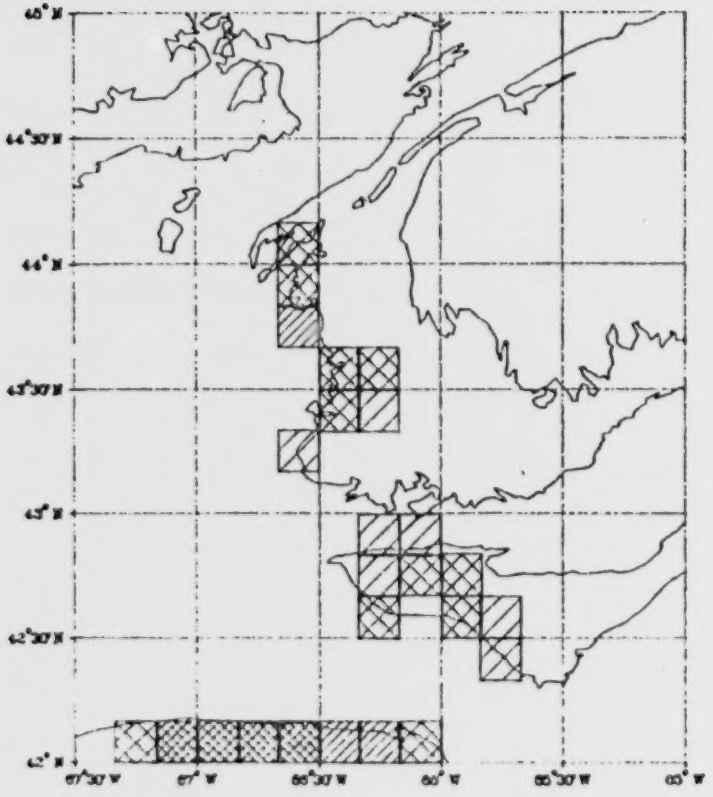

4X CATCH 1983
45° N
44°30' N
44° N
43°30' N
43° N
42°30' N
42° N
67°30' W
67° W
66°30' W
66° W
65°30' W
65° W
4X CATCH 1984
45° N
44°30' N
44° N
43°30' N
43° N
42°30' N
42° N
67°30' W
67° W
66°30' W
66° W
65°30' W
65° W

Figure 5.

4X CATCH 1985



4X CATCH 1986

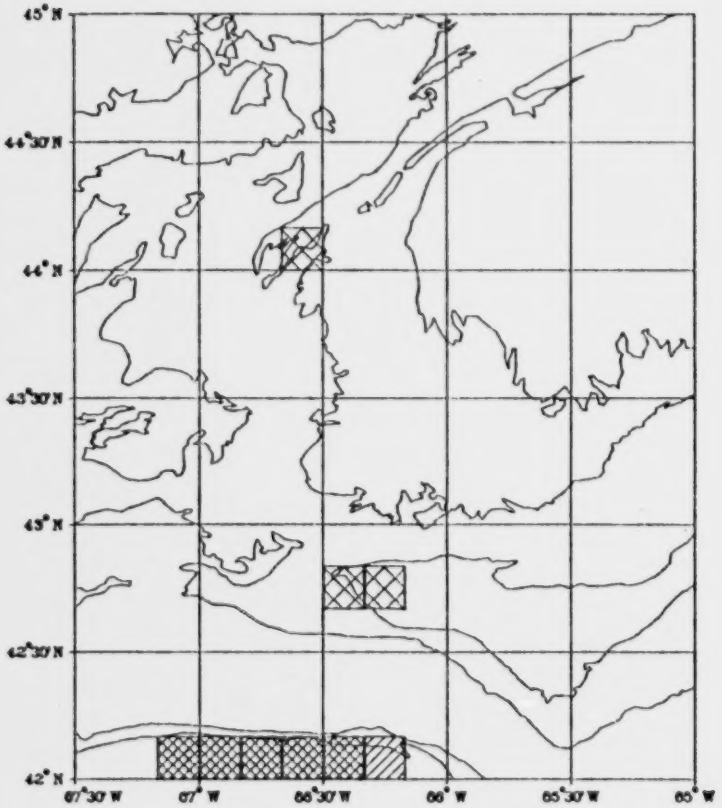


Figure 5.

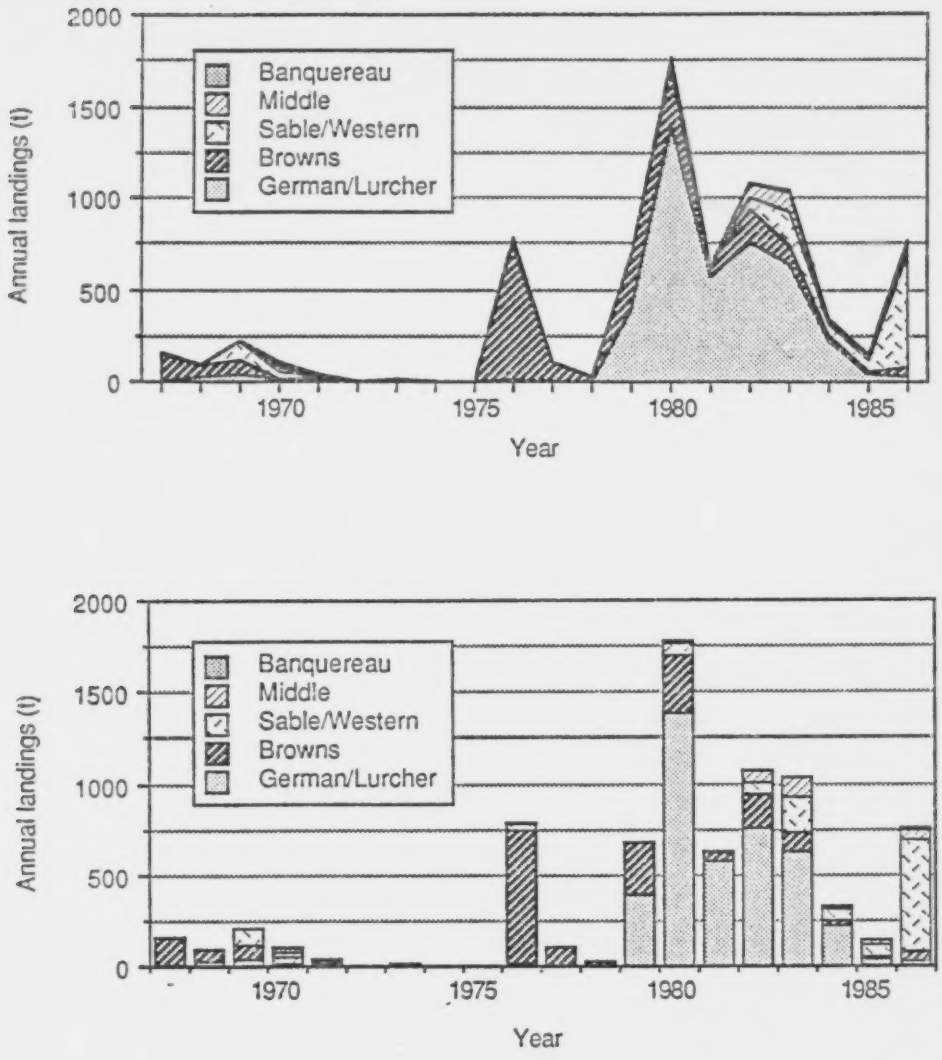


Figure 6.- Long term trends in annual landings (t of scallop meats) for the Scotian Shelf illustrated as a cumulative area graph and in a stack wise fashion. Overall the German / Lurcher area has been the major contributor; however, Western Bank and the Sable Island area have increased in importance over the last five years.